Biodiesel Production from Waste Cooking Oil using Heterogeneous Catalyst & its Purification using an Organic Adsorbent

Short Synopsis

Submitted in partial fulfillment of the requirement of the degree of

DOCTOR OF PHILOSOPHY

By

Monika

Regd. No.- MRUCHDN012K210013

Under the supervision of

Dr. Sangita Banga, (Professor)

Department of Sciences (Chemistry)

Co-Supervisor

Dr. Vinayak V. Pathak, Manager

EnviorNet Pvt. Ltd.

Department of Sciences (Chemistry)

School of Sciences

MANAV RACHNA

MANAV RACHNA UNIVERSITY

Declared as State Private University vide Haryana Act 26 of 2014

MANAV RACHNA UNIVERSITY

Sector-43, Aravali Hills, Faridabad

Year 2023

Scanned with CamScanner

MANAV RACHNA UNIVERSITY

Declared as State Private University vide Haryana Act 26 of 2014

MANAV RACHNA UNIVERSITY

Sector-43, Aravali Hills, Faridabad

Date:21.06.2023

DECLARATION BY THE SCHOLAR

I hereby declare that the short synopsis entitled *"Biodiesel Production from Waste Cooking Oil using Heterogeneous Catalyst & its Purification using an Organic Adsorbent"* being submitted in partial fulfillment of the requirement for the degree of Doctor of Philosophy in the Department of Sciences (Chemistry) under the School of Sciences of Manav Rachna University, Faridabad during the academic year 2022-23.

It is the work that is expected to be carried out under the supervision of Prof. Dr. Sangita Banga, and co-supervision of Dr. Vinayak. V. Pathak.

Further, it is declared that the short synopsis is within the plagiarism limit and copy of the same is attached as per the University norms.

Monika

Registration Number - MRUCHDN012K210013

Scanned with CamScanner

MANAV RACHNA UNIVERSITY
Declared as State Private University vide Haryana Act 26 of 2014

MANAV RACHNA UNIVERSITY
Sector-43, Aravali Hills, Faridabad

Date: 21.06.2023

CERTIFICATE BY SUPERVISOR(S)

This is to certify that, the short synopsis entitled *"Biodiesel Production from Waste Cooking Oil using Heterogeneous Catalyst & its Purification using Organic Adsorbent"* is an original piece of work done by research scholar Monika under the supervision of Prof. Dr. Sangita Banga and co-supervision of Dr. Vinayak. V. Pathak for the degree of Doctor of Philosophy in the Department of Sciences (Chemistry) under the School of Sciences of Manav Rachna University, Faridabad during the academic year 2022-23.

Further, it is certified that the short synopsis is within the plagiarism limit and copy of the same is attached as per the University norms.

Supervisor
Prof. Dr. Sangita Banga
Manav Rachna University

Co-Supervisor
Dr. Vinayak V. Pathak
EnviorNet Pvt. Ltd.

Scanned with CamScanner

ABSTRACT

Energy sector is a very crucial sector for the development of any country. As population is increasing very rapidly, the requirement of energy has been increased, leading to depletion of fossil fuels. As we know, fossil fuels are limited in supply and non-renewable, an alternative of these conventional fossil fuels is the need of the hour. Biodiesel is the most promising emerging alternative of conventional fossil fuels. Waste cooking oil (WCO) is a very economical and convenient feedstock for the production of biodiesel. Biodiesel is produced from WCO by the transesterification reaction in which alcohol and a catalyst is added to the WCO to produce biodiesel and glycerol. This study includes transesterification of waste cooking oil to produce biodiesel using various heterogenous catalyst and its purification using an organic adsorbent.

Keywords - biodiesel; heterogeneous catalyst; waste cooking oil; transesterification; purification

CONTENTS

S. No.	Description	Page No.
1	Introduction	1-2
2	Literature Review	3-14
	2.1 Feedstock for Biodiesel Production	3-5
	2.2 Biodiesel Production Methods	5-6
	2.3 Types of Transesterification Reaction	7-10
	2.4 Factors Affecting Biodiesel Production	10-13
	2.5 Biodiesel Purification Methods	13-14
3	Objectives of the Study	14
4	Materials and Methodology	14-15
5	Significance and Novelty of Proposed Work	15
6	Expected Outcome of the Research	15
7	References	16-19

1. INTRODUCTION

For the development of any country, energy resources play an important role. In transportation and industry sector, requirement of fuel is increasing by each passing day. This will lead to depletion of conventional energy resources. Our current energy requirement is mainly dependent on fossil fuels, which are limited in availability and have adverse environmental impact. These fossil fuels release harmful greenhouse gases and other air pollutants which are responsible for global warming and air pollution. Development of alternative energy resources is the need of the hour to ensure sustainable energy generation. Renewable energy resources such as solar, wind, geothermal, bioenergy and others are playing important role in supply of energy. However, biomass-based energy generation is considered as the best alternative of the conventional fuels.

Biofuels is the form of bioenergy, which are renewable which release less gaseous pollutants and affordable in compare to conventional fossil fuels. Many countries such as Brazil, Indonesia, China, Malaysia, Germany and Thailand have adopted biofuels as a major transportation fuel (Gaur et al., 2020). Among different biofuels, biodiesel is widely used fuel in different sectors such as transportation, industrial and agricultural sector. In developing country like India, replacement of conventional diesel by biodiesel can play significant role in Indian energy sector. Chemically, biodiesel is the fatty acid methyl esters (FAME), which is produced from transesterification of fatty acids. Physical and chemical properties of the biodiesel is quite similar to petroleum-based diesel. Biodiesel is produced from biodegradable, renewable and less toxic biomass feedstock like edible oils, non-edible oils, waste cooking oil, microalgae etc. It can be used in existing diesel engine in raw form or in blended form with or without any mechanical modifications. Combustion of biodiesel releases less carbon monoxide and particulate matter; hence it is greener than the conventional biodiesel. Biodiesel increases the operational life of an engine, as it has lubricating properties. Moreover, biodiesel is less volatile as it has higher boiling point, thus it's transportation and storage is easy (Costa et al., 2020).Biodiesel is carbon neutral because the amount of carbon dioxide released by its combustion is almost equal to the carbon dioxide gas absorbed by the oil seed. As it is an oxygenated fuel as it contains 10-15% of oxygen by weight, which provides complete combustion of fuel thereby increasing its emission profile.

Waste Cooking oil (WCO) serves as a potential feedstock for production of biodiesel due to its wide availability, lesser cost than another feedstock. Large amount of waste cooking oil is produced from fast-food restaurants, post-processing factories, and others (Cordero-Ravelo & Schallenberg-Rodriguez, 2018). These waste cooking oils are further utilized as cooking oil after its processing and refining. It is found that consumption of waste cooking oi has serious health hazards such as cancer, cardiac diseases, obesity, diabetes etc (Cordero-Ravelo & Schallenberg-Rodriguez, 2018). A large quantity of waste cooking oil is generated and most of it is either disposed off into dustbin or drainage system or onto soil. Their disposal creates many environmental issues also. Instead of disposing, WCO can be used as a feedstock for biodiesel production. Using WCO as a feedstock for biodiesel production will makes the process very economical, due to its low cost. Moreover, in comparison to edible oils, WCO does not create food vs fuel crisis, it is easily available and does not cause any environmental issue.

India's National Policy on Biofuels has proposed a target of 5% biodiesel blending in petroleum derived diesel by 2030. Under this policy, the Food Safety and Standards Authority of India (FSSAI) has taken an initiative for collection and conversion of WCO into biodiesel under their program named 'Repurpose Used Cooking Oil' (RUCO) launched in 2021. Under this program, WCO has been collected from restaurants, college hostels and cottage industries by a FSSAI authorized aggregator for a specified price and then sent for conversion into biodiesel. Right now, India has approx. 44 biodiesel manufacturers situated in various states like Maharashtra, Rajasthan, Andhra Pradesh, Tamil Nadu, Haryana etc.

Some methods of generation of biodiesel from WCO are pyrolysis, transesterification and supercritical methods. Among these methods, transesterification process is the most adaptive method for biodiesel production in which biodiesel and glycerol as a by-product is obtained from the feedstock oil. But there is a challenge with WCO that it has very high FFA and water content making its transesterification reaction very difficult. So WCO has to give pretreatment or esterification with an acid first before its transesterification reaction (Talebian-Kiakalaieh et al., 2013). Transesterification reaction is carried out in the presence of a catalyst. The catalyst can be homogenous, heterogenous or enzyme. Now-a-days more research is focused on heterogenous catalyst, as it can be recollected and reused, so that the overall cost of production of biodiesel can be minimized. This present study involves advantages of biodiesel production from waste cooking oil using heterogenous catalyst. Very few reports/data are

available on optimization of production of biodiesel using waste cooking oil in the presence of heterogeneous catalyst which is also an aim of the present study.

2. REVIEW OF LITERATURE

2.1 Feedstocks for Biodiesel Production

Biodiesel is synthesized from various feedstocks such as edible oil, non-edible oil, waste cooking oil, microalgae etc. On the basis of types of feedstocks**,** biomass feedstocks are categorized into four categories i.e. first generation, second generation, third generation and fourth generation feedstocks, as described in table no. 01. First generation feedstocks include conventional edible vegetable oil such as rapeseed, soybean oil, palm oil, sunflower oil, coconut oil etc. A lot of research has been done on biodiesel production from edible vegetable oil (Gaur et al., 2020). Commercial viability of first generation feedstock is well established, however food vs fuel dilemma and requirement of agricultural land are major challenges (Singh et al., 2019).

Second generation feedstocks involves lignocellulosic biomass, non-edible food crops, organic waste and oils such as jatropha, jojoba, cotton seed, waste cooking oil (WCO), restaurant grease, animal fats such as pork land, beef tallow etc (Utlu, 2007). As there will be no food vs fuel crisis with these feedstocks and they do not directly affect human food supply chain, so these are better options for conversion into biodiesel. As these feedstocks can be grown in wasteland, less farmland is required and a mixture of food crops can be grown in a particular land, these are more efficient and more environment friendly for biodiesel production. From second generation feedstocks, useful byproducts are produced during the transesterification reaction (Suzihaque et al., 2022).

Third generation feedstocks involve aquatic biomass such as algae and seaweeds. Microalgae are the best source of lipids for large scale production of biodiesel, their cultivation is very easy due to their fast cell growth (Ahmad et al., 2011).It has 25 times higher yield of oil than other terrestrial plants. It can be grown in non-arable land which are not fit for conventional agriculture (Davoodbasha et al., 2021). Moreover, useful byproducts are produced like carbohydrates, biopolymers etc. which can be used in various ways like as a feed or fertilizer. But not much research has been done on this due to their high capital cost.

Fourth generation feedstocks include genetically engineered or modified biomass for higher solar energy and carbon dioxide capture. It includes electro fuels and photobiological solar fuels. These feedstocks are less controversial as they don’t have any negative effect on environment

(Singh et al., 2019). There is not a lot of research on these feedstocks due to high initial investment, slow yield and very long processing time. This generation feedstocks have many benefits like it is easily available, inexhaustible, cheap and have high energy content. This uses technology of artificial photosynthesis and direct solar biodiesel production. It is based on synthetic biology technique.

Among different feedstocks discussed above waste cooking oil offers various advantages such as no land requirement, no requirement of oil extraction or processing of biomass feedstock.

Table 01. Advantages and disadvantages of different generation of biomass feedstock

Feedstock	Advantages	Disadvantages	Important Feedstock
First Generation	Easily available, easy conversion	Food vs fuel crisis, low crop yield, low area of cultivation, less adaptability of harsh environmental conditions	Coconut oil, olive oil, sunflower oil, soybean, Rice bran, Mustard oil, Palm oil, Rapeseed, walnut, hazelnut, Cashew nut, corn
Second Generation	Does not affect food supply, less production cost, can be grown on non-arable land	Less cost-effective process, low crop yield	Jojoba oil, Mahua indica, Karanja, Neem, Jatropha circus, milk bush, Rubber seed, silk cotton seed, Petroleum nut, babassu tree
Third Generation	Does not affect food supply, high growth rate of algae	Algae cultivation needs high energy, costly oil extraction process from algae, low lipid content of algae	Animal Tallow, Fish, Poultry fat, chicken fat, Cholera vulgaris algae
Fourth Generation	High Lipid content, high growth rate, high energy content high CO_2 absorbing ability	Very low research, high initial investment	Electro biofuels, synthetic cell, photobiological solar biodiesel

2.2 **Biodiesel Production Methods:** The precursor of biodiesel i.e., fatty acid cannot be used directly as a fuel due to their high viscosity and density. Thus, they require chemical processing for conversion into fuel. Various methods have been reported for biodiesel production such as blending, pyrolysis, microemulsion and transesterification as shown in table no 02. In blending process, feedstock oil is first preheated to 55 °C, which decreases the viscosity of that oil. For their dilution, any solvent, petroleum derived diesel or ethanol is added, which reduces the density and viscosity of the feedstock oil (Nainwal et al., 2015).Whereas in microemulsion process oil is solubilized in surfactant and solvent till the attainment of required viscosity. Biodiesel with high cetane number is obtained through this method and contains surfactants, alcohols, oils and diesel fuels (Kirubakaran & Arul Mozhi Selvan, 2018). In pyrolysis, the crude oil is first preheated and then discomposed under high temperature in the presence or absence of a catalyst. The biodiesel obtained with this method has similar properties as that of traditional diesel (Yaman, 2004). Transesterification is the most common method for biodiesel production. It involves reaction between triglycerides (feedstock oil) and alcohol to produce alkyl esters and glycerol in the presence or absence of a catalyst. In this chemical reaction, 03 moles of alcohol and one mole of triacylglyceride (TAG) yields three moles of alkyl esters (biodiesel) and one mole of glycerol as a byproduct. Adding excess alcohol shifts the equilibrium towards right side i.e. product side leading to more production of alkyl esters (Davoodbasha et al., 2021). Being the reversible reaction, this reaction is affected by a number of factors like type of catalyst, catalyst amount, reaction conditions, alcohol to oil ratio and the source of triglycerides i.e. the feedstock (Foroutan et al., 2020). Chemical reaction showing the conversion of triglycerides into esters is showing in the fig. 1. This method is used in laboratory as well as on industrial scale, as it needs low pressure, low temperature simple process, fast reaction and gives high conversion yield (Gebremariam & Marchetti, 2017).

Table 2: Different pathways of biodiesel production

Method of Biodiesel production		Blending	Pros	Easy Process
			Cons	Problem of carbon deposits, gum formation and high smoke, CO, HC emission
		Pyrolysis	Pros	Easy Process
			Cons	High temp, required, high carbon residue, low purity biodiesel, high installation cost
		Reactive distillation	Pros	Easy process, product separation easy, high FFA con be processed, low alcohol requirement
			Cons	High energy requirement
		Transesterification	Pros	Produced biodiesel has comparable properties as that of petro-diesel, favorable for commercial biodiesel production
			Cons	Not reusable catalyst, less efficiency of conversion
		Micro emulsion	Pros	Easy process
			Cons	Problem of carbon deposits, incomplete combustion higher viscosity

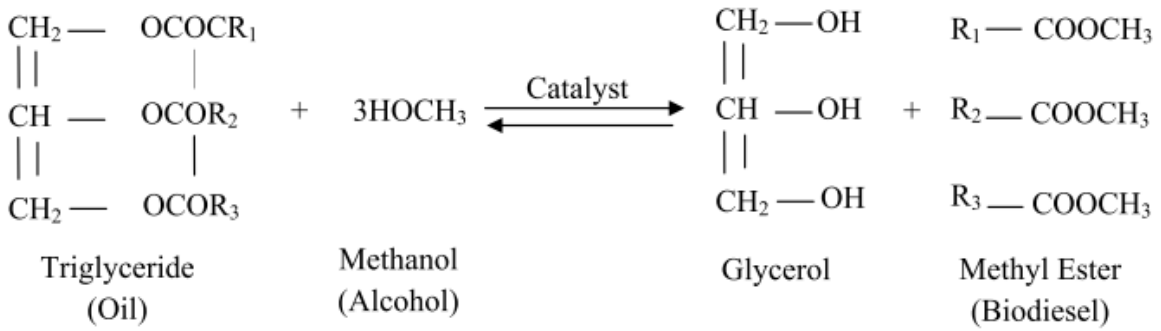

Fig. 1: Transesterification reaction of triglycerides (Oil) with an alcohol

2.3 Types of Transesterification Reaction: -Transesterification process can occur by three ways: - by non-catalyzed, chemically catalyzed (Homogenous & Heterogenous catalysts) and enzymatic catalyzed reaction. Table 03 shows the advantages and disadvantages of all the three methods.

2.3.1 Non-Catalytic Transesterification Reaction: -Transesterification reaction in the absence of a catalyst needs very high temperature, pressure and time, which will ultimately increase the cost of the whole process of biodiesel production. Therefore, for commercial purpose, it is not considered as a good option of biodiesel production.

2.3.2. Chemically Catalyzed Transesterification: - Chemically catalyzed transesterification reaction is further classified into homogenous and heterogenous catalysis.

- **Homogenous Catalysis**: - Conventional homogenous catalyst includes acidic and alkaline catalyst. In case of alkaline catalysts, most commonly used catalysts are NaOH, KOH and $NaOCH_3$ and in case of acidic catalysts sulphuric acid, hydrochloric acid, sulphonic acid are mostly used. Homogenous catalysts have a big disadvantage that it cannot be separated from reaction mixture and thus it cannot be reused. Moreover, there is more waste generation with homogenous catalysis. Moreover, acidic homogenous catalysts cause corrosion of equipment and are not eco-friendly. Basic homogenous catalysts cause saponification in case of high FFA oil and leads to low yield. Thus, heterogenous catalysts have more advantage over homogenous catalysts, as the former are diphasic and thus can be removed easily from the reaction mixture.

- **Heterogenous Catalysis:** - As homogenous catalysis leads to high production cost due to the saponification problem, the heterogeneous catalysis is a low-cost process. Moreover, heterogenous catalysts can be reused and can tolerate high water & FFA content also without any problem of saponification (Lam et al., 2010). As heterogenous catalysts are diphasic, there is no need of washing steps for the reuse of the catalyst, but due to leaching their activity decreases making the reuse of the catalyst very difficult. Acidic heterogenous catalysts are non-corrosive and are ecofriendly. Moreover, in case of heterogenous catalysts, there is less waste generation. Thus, heterogenous catalysts are a good option for the commercial production of biodiesel.

Table 3: Advantages vs disadvantages of various catalyst employed in the transesterification reaction

Catalytic Transesterification process										Non-Catalytic (Supercritical alcohol)	
Homogenous				Heterogenous				Enzymatic			
Acidic Catalyst		Basic Catalyst		Acidic Catalyst		Basic Catalyst					
Advantage	**Disadvantage**	**Advantage**	**Disadvantage**	**Advantage**	**Disadvantage**	**Advantage**	**Disadvantage**	**Advantage**	**Disadvantage**	**Advantage**	**Disadvantage**
Better Catalysis	Slow rate of reaction	High rate of reaction	Saponifica-tion in case of high FFA oil	Catalyst easy to separate	Costly catalyst	Reusable catalyst	Expensive	Highly purified product	high-cost operation	Super-fast reaction	High-cost process
Not Sensitive towards & FFA content	Corrosion of Equipment	More active		can be reused	Severe reaction	easy separation of products	Saponification in case of High FFA Content	Easy Product separation	Methanol may deactivate enzyme activity	No waste generation	High temp and pressure
	Not eco friendly	Wide availability	Not reusable	Eco friendly	High Temp. required	Low generation of waste		Mild reaction		Easy purifica-tion of product	Needs High amount of alcohol
-	Not reusable	cheap catalyst	Low yield	Non-corrosive nature	Large amount of catalyst required	high yield	Large amount of catalyst required	High selectivity and yield	Enzymes sensitive towards temp	High yield	
-	High reaction temperature required	High yield	-	High yield	High amount of alcohol required	Non corrosive nature	High amount of alcohol required	needs less quantity catalyst		-	-

Table 04: Different catalysts used for transesterification reaction of WCO

Type of Catalyst	Catalyst	Catalyst Conc.	Reaction time	Reaction Temp	Methanol to Oil Ratio	Yield (%)	Reference
Homogenous	H_2SO_4	41.8	4 hr	70	245:1	99	(Lam et al., 2010)
	KOH	1.30%	1 min	62.4	1:9.4	98.6	(Sharma et al., 2020)
	NaOH	1.1 %	0.33 hr	60	7:1	88.8	(Lam et al., 2010)
Heterogenous	CaO	1	1.5	50	8:01	96	(Sharma et al., 2020)
	Ferric Maganese Doped Tungstated Zirconia nano particles	4	4 hr	200	1:25	96	(Alhassan et al., 2016)
	Golden apple	10	60	60	18:1	83	(Viriya-empikul et al., 2010)
	Kettle Limescale	8.90%	15 min	61.7	3:1.7	93.4	(Aghel et al., 2019)
	Rice husk (RHA 800)	7%	4 hr	-	9: 1	91.5	(Chen et al., 2015)
	Waste eggshell	5%	2 hr	70	12:01	97.1	(El-Gendy & Deriase, 2015)
	Zn substituted CaO nanocatalyst derived from waste egg shell	5%	4 hr	65	20:1	96.74	(Borah et al., 2019)
Enzymatic	Novozyme 435	0.75	60 min	32.5	6:1	95.9	(Online et al., 2016)

Apart from these commercial used heterogenous catalysts, some bio-based catalysts derived from any waste source can also be used for the transesterification reaction. Some reported waste sources are eggshell, bones, mollusk shell, banana peel and rice husk (Viriya-empikul et al., 2010). Thus, a catalyst derived from any bio-based waste can also be studies to make the biodiesel production completely green and environment friendly. Some important reported catalysts used during transesterification of waste cooking oil are listed in table no. 04.

As waste cooking oil contains very high FFA content, this will create saponification with alkaline catalysts, thereby decreasing biodiesel yield and separation of products difficult. WCO having high water content also causes saponification problem. These problem creates limited application of alkaline catalysts in case of transesterification reaction (Kulkarni & Dalai, 2006).

But if alkaline catalyst is used with waste cooking oil, the oil has to be pretreated with an acid i.e., esterification has to be carried out before transesterification to reduce free fatty acid content of oil.

2.3.3. Enzymatic Transesterification: - Transesterification reaction can be carried out in the presence of enzymes. Lipase is a commonly used enzyme which is obtained from different microorganisms (Costa et al., 2020). In this case conversion is very high with very moderate reaction conditions. In enzymatic biodiesel production, there is no problem of saponification leading to high quality glycerol as a byproduct. Only disadvantage of using enzymes as a catalyst is requirement of their high dosage and slow reaction rate of transesterification. Moreover, the enzymes cannot be reused for the transesterification reaction, as their separation from product obtained is very difficult, which leads to high cost of biodiesel production.

2.4 Factors Affecting Biodiesel Production: - Some factors which affects transesterification reaction are described below in detail.

2.4.1 Type of Alcohol: - 03 moles of alcohol are needed for the transesterification of one mole of feedstock oil. Methanol & Ethanol are commonly used alcohol during transesterification reaction, due to their low price. If methanol is used, biodiesel product obtained will be fatty acid methyl ester (FAME) & if ethanol is used, it will be fatty acid ethyl ester (FAEE). Moreover, FAME has higher maximum engine performance in comparison to FAEE. Methanol is cheap & more reactive as compared to ethanol. FAME produced by this is more volatile than FAEE. Moreover, FAEE is more viscous than FAME. Methanol is the most efficient alcohol for transesterification reaction. Biodiesel production using Methanol has more cost benefits over other alcohols, as this is very cheap alcohol and can be used for commercial production. But the amount of methanol used should be optimum (Gebremariam & Marchetti, 2017). If less quantity of methanol is used, rate of reaction will be slow, but if more quantity of methanol is used, it will lead to difficult separation of byproduct (Glycerin). Advantages and disadvantages of various alcohol used during the transesterification reaction is listed in fig. 02.

2.4.2 Reaction Temperature: - With the increase in reaction temperature, production yield increases and reaction time decreases. Moreover, with increase in temperature, there is decrease in oil viscosity also (Tamjidi et al., 2021). On increasing the temperature from 50 °C to 70 °C, there is an enhancement in biodiesel production efficiency of upto 94.25% from 41.28%. The optimum temperature for the transesterification reaction of WCO is 60 °C (Topare et al., 2021).

However, some research shows that in case of WCO having high FFA content, the optimum temperature is 75 ˚C (Al-Saadi et al., 2020). Some research shows that in case of WCO having low FFA, the optimum reaction temperature is 65 °C (Farooq & Ramli, 2015).

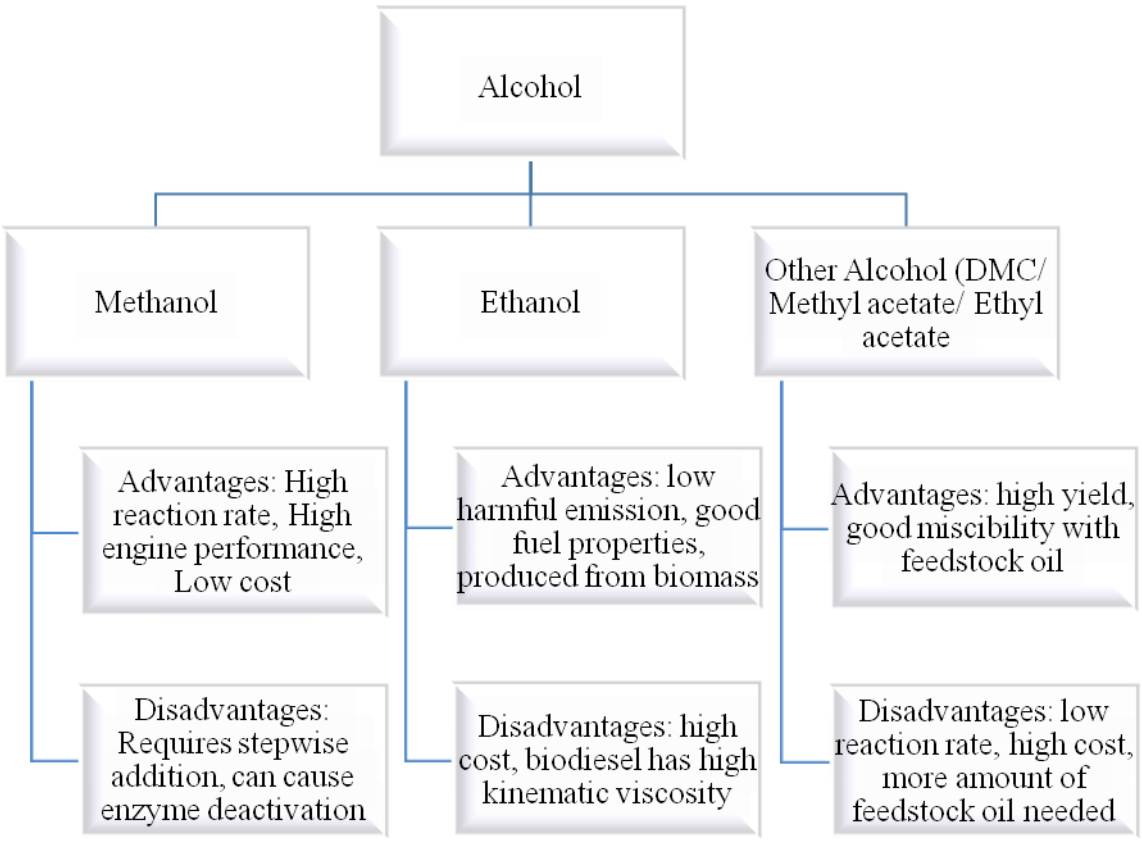
Alcohol
Methanol
Ethanol
Other Alcohol (DMC/ Methyl acetate/ Ethyl acetate
Advantages: High reaction rate, High engine performance, Low cost
Advantages: low harmful emission, good fuel properties, produced from biomass
Advantages: high yield, good miscibility with feedstock oil
Disadvantages: Requires stepwise addition, can cause enzyme deactivation
Disadvantages: high cost, biodiesel has high kinematic viscosity
Disadvantages: low reaction rate, high cost, more amount of feedstock oil needed

Fig. 2: Different alcohols used for transesterification reaction

2.4.3 Reaction Time: - It is the most crucial parameter which determines the yield of the biodiesel. Salimi researched about the effect of reaction time on transesterification reaction using $ZnO/BiFeO_3$heterogenous catalyst by monitoring 2 hr., 4 hr., 6 hr.& 8 hr. reaction time, which proved that with increasing reaction time from 2 hr to 6 hr, rate of transesterification reaction increases (Salimi & Hosseini, 2019). It is found that the optimum reaction time is 6 hr. for transesterification reaction at which there is maximum biodiesel yield of about 95.43% is obtained (Salimi & Hosseini, 2019). Effect of reaction time on biodiesel production using $ZnO/BiFeO_3$ heterogenous catalyst was studied, which showed that the optimum reaction time is 6 hr. at which there is maximum biodiesel production efficiency of 95.43% (Salimi & Hosseini, 2019). Table no. 04 shows the optimum reaction time for the transesterification reaction of waste

cooking oil using different homogenous, heterogenous and enzymatic catalysis. Research shows that the optimum time for the transesterification reaction of WCO is 60 min (Topare et al., 2021). However, in case of WCO having high FFA content, the optimum reaction time is 5 hr (Al-Saadi et al., 2020). Some studies shows that the WCO having low FFA content, optimum reaction time for the transesterification reaction is 4 hr (Farooq & Ramli, 2015).

2.4.4 Alcohol to Oil Ratio: -Normally 1 mole of triglyceride and 3 moles of alcohol are needed to produce one mole of alkyl ester and one mole of glycerol. But as Le-chateliers principle states that to obtain high yield of product, increase the concertation of reactants. Thus, higher the alcohol to oil ratio, higher will be biodiesel production (Mathiyazhagan & Ganapathi, 2011). But if the alcohol to oil ratio is increased beyond the optimum level, there will be no effect on biodiesel production, thus will increases the cost of production only. The optimum alcohol to oil ratio for transesterification reaction of waste cooking oil is 6:1 (Topare et al., 2021). Some studies shows that the optimum ratio of alcohol to oil for transesterification reaction of WCO having high FFA content is 10:1 (Al-Saadi et al., 2020) and of WCO having low FFA content is 15:1 (Farooq & Ramli, 2015).

2.4.5 Catalyst Concentration: - Biodiesel yield increases with the increase in catalyst concentration due to increase in the available surface area of catalyst. But if the catalyst concentration is increased beyond the optimum level, there is decrease in biodiesel yield due to increase in the viscosity of reaction mixture. But in case of low catalyst concentration, there would be no complete conversion of triglycerides into biodiesel. Therefore to find out the optimum catalyst concentration is a very crucial factor for transesterification reaction (Mathiyazhagan & Ganapathi, 2011). Effect of catalyst concentration on biodiesel production using CaO/Fe_3O_4 heterogenous catalyst has been studied, which proved that the optimum catalyst concentration is 10% for the biodiesel production (Seffati et al., 2019). Table no. 04 shows the optimum catalyst concentration for the transesterification reaction of waste cooking oil using different homogenous, heterogenous and enzymatic catalysis.

2.4.6 Stirrer Speed :- Mixing of the reactants in a reaction is very important part, as agitation will increase the collision between particles (Chakraborty et al., 2011). On increasing stirring speed, reaction occurs fast and conversion increases. In order to achieve thorough and equal mixing of the feedstock, the blending intensity must generally be raised. Exclusive mechanical mixing is needed when the feedstock's viscosity is very high to overcome the unfavorable impact

of viscosity on the mass transfer between oil and alcohol (S et al., n.d.). Speed of agitation is crucial for the production of the biodiesel as agitation of the oil and catalyst mixture speeds up the reaction. For instance, while other parameters were held constant, the mixing intensities used at 200, 400, 600, and 800 rpm for 60 min. A greater conversion of the finished product was attained at 400 rpm. lower stirring speed indicates reduced product production. For this reason, there is different optimum speed for different types of feedstocks.

2.5 Biodiesel Purification Methods: - As the biodiesel obtained by transesterification contains many impurities of free glycerol, excess alcohol, soap and remaining catalyst, its purification is must needed. As impure biodiesel can damage diesel engine by accumulating impurities in the nozzles leading to its corrosion, its purification is a very important step. There are many methods of biodiesel purification listed below: -

- **Wet Washing: -**Distilled water or slightly acidic water is used in this method. The impurities of glycerol and excess alcohol are removed by this method (Stojković et al., 2014). In this method, the impure biodiesel is shifted to separating funnel. After that it is washed with distilled or acidic water many times. The upper layer having purified biodiesel separated from the lower layer having wastewater.
- **Dry Washing: -**It is the water free washing method. Some washing agents like acid resins and adsorbents are employed in this method. The impure biodiesel is mixed with adsorbent material and stirred for some time. The excess alcohol, glycerol and other impurities are removed by this method (Dias et al., 2008).
- **Membrane Extraction: -** Any organic or inorganic membrane is used to remove impurities from crude biodiesel. Most commonly ceramic membrane is used with the organic solvent. Impurities of soap and excess alcohol are removed by this method (Atadashi et al., 2011). The process is simple and flexible. But this method is costly process and increases the overall cost of biodiesel production.
- **Precipitation:-**Any precipitating agent like oxalic acid or citric acid is mixed with crude biodiesel to remove impurities of calcium ions (Dias et al., 2008). The precipitate of calcium ions is removed by filtration. High yield of pure biodiesel is obtained by this method. But this method depends on the operating conditions.
- **Complexation: -** Any complexing agent like ethylenediaminetetraacetic acid (EDTA) is mixed with the impure biodiesel to remove any impurity of calcium ions. The calcium

ions form a stable EDTA complex. But aqueous EDTA solution is difficult to prepare. Moreover, EDTA is a hazardous substance (Atadashi et al., 2011).

All these conventional methods of purification of biodiesel, are costly and increases the overall production cost of biodiesel. So, to find out the alternative of these methods, which should be highly efficient, do not compromise the quality of pure biodiesel, biodegradable or natural product is the need of the hour. We will try to find out a natural adsorbent for the purification of the biodiesel produced, which should be cost effective and environment friendly.

3. OBJECTIVES OF THE STUDY

- Physiochemical characterization of collected and synthesized waste cooking oil (WCO) for biodiesel production.
- To investigate the influence of heterogeneous catalyst (any novel heterogenous catalyst and a catalyst from organic source) for the synthesis of biodiesel.
- Optimization of process parameters for improvement of yield of biodiesel.
- To purify the obtained biodiesel using an organic adsorbent.

4. MATERIAL AND METHODOLOGY

Materials Required: -

- Waste cooking oil from local restaurants
- Raw cooking oil
- Hot plate with magnetic stirrer
- Chemicals- Methanol, Sulfuric acid, urea, KOH etc.
- Glassware- round bottom flask, separating funnel and all the glassware for transesterification reaction.

Methodology to be adopted: -

Step 1: C**ollection of WCO & its characterization**– WCO would be collected from local restaurants of Faridabad and its physiochemical characterization would be carried out like acid value, saponification value, density, viscosity etc.

Step 2: Preparation of WCO by applying 5/10 heating cooling cycles to raw vegetable oil & its characterization- Repeated heating and cooling cycles would be given to raw vegetable oil up to 10^{th} cycle. After each frying cycle, physiochemical properties of oil would be calculated like acid value, saponification value, density, viscosity etc.

Step 3: Transesterification reaction: WCO collected from local restaurants would be trans-esterified using heterogenous catalyst. One heterogenous catalyst would be made from any organic source and other would be made from any chemical. Optimization of the transesterification reaction would be carried out with both of the heterogenous catalyst.

Step 4: Characterization of biodiesel: Produced biodiesel would be characterized by physiochemical as well as instrumentation methods. For most of the physiochemical characterization like acid value, saponification value, iodine value titration methods would be used. For instrumentation characterization, Fourier transform infrared spectroscopy (FTIR), gas chromatography mass spectrometer (GCMS) of the produced biodiesel would be carried out.

Step 5: Purification of biodiesel: The produced biodiesel would be purified using any commercial adsorbent and any organic adsorbent made from any organic source in the lab. Comparison of both of the adsorbents would be carried out.

5. SIGNIFICANCE AND NOVELTY OF PROPOSED WORK

Traditional fossil fuels releases very harmful gases in the environment leading to global warming. Also, these fossil fuels are limited in supply and non-renewable also. Replacing these fuels with the biodiesel will clean the environment and also makes easy availability of these fuels to every individual of the country. But the production of biodiesel from WCO is not that cheap for its commercial production. In the given study, comparison of any metal oxide heterogenous catalyst and an organic catalyst is investigated to find out the catalyst giving maximum yield at less cost. Further, an organic adsorbent will be used for biodiesel's purification to minimize the cost of biodiesel production from WCO for its commercial production.

6. EXPECTED OUTCOME OF THE RESEARCH

After the completion of objectives of present study, we can propose cost effective method for WCO based biodiesel production. Heterogeneous catalyst based on waste biomass would be a cost effective and recoverable with little or no environmental impact. Further optimization studies and LCA analysis will help in the exploration of different aspects of WCO based biodiesel production.

7. REFERENCES

Aghel, B., Mohadesi, M., Ansari, A., & Maleki, M. (2019). Pilot-scale production of biodiesel from waste cooking oil using kettle limescale as a heterogeneous catalyst. *Renewable Energy*, *142*, 207–214. https://doi.org/10.1016/J.RENENE.2019.04.100

Ahmad, A. L., Yasin, N. H. M., Derek, C. J. C., & Lim, J. K. (2011). Microalgae as a sustainable energy source for biodiesel production: A review. *Renewable and Sustainable Energy Reviews*, *15*(1), 584–593. https://doi.org/10.1016/j.rser.2010.09.018

Al-Saadi, A., Mathan, B., & He, Y. (2020). Biodiesel production via simultaneous transesterification and esterification reactions over SrO–ZnO/Al2O3 as a bifunctional catalyst using high acidic waste cooking oil. *Chemical Engineering Research and Design*, *162*, 238–248. https://doi.org/10.1016/J.CHERD.2020.08.018

Alhassan, F. H., Rashid, U., & Taufiq-Yap, Y. H. (2016). Ferric-manganese doped sulphated zirconia nanoparticles catalyst for single-step biodiesel production from waste cooking oil: Characterization and optimization. *International Journal of Green Energy*, *13*(13), 1305–1313. https://doi.org/10.1080/15435075.2014.966267

Atadashi, I. M., Aroua, M. K., & Aziz, A. A. (2011). Biodiesel separation and purification: A review. *Renewable Energy*, *36*(2), 437–443. https://doi.org/10.1016/j.renene.2010.07.019

Borah, M. J., Das, A., Das, V., Bhuyan, N., & Deka, D. (2019). Transesterification of waste cooking oil for biodiesel production catalyzed by Zn substituted waste egg shell derived CaO nanocatalyst. *Fuel*, *242*(January), 345–354. https://doi.org/10.1016/j.fuel.2019.01.060

Chakraborty, R., Bepari, S., & Banerjee, A. (2011). Application of calcined waste fish (Labeo rohita) scale as low-cost heterogeneous catalyst for biodiesel synthesis. *Bioresource Technology*, *102*(3), 3610–3618. https://doi.org/10.1016/J.BIORTECH.2010.10.123

Chen, G. Y., Shan, R., Shi, J. F., & Yan, B. B. (2015). Transesterification of palm oil to biodiesel using rice husk ash-based catalysts. *Fuel Processing Technology*, *133*, 8–13. https://doi.org/10.1016/j.fuproc.2015.01.005

Cordero-Ravelo, V., & Schallenberg-Rodriguez, J. (2018). Biodiesel production as a solution to waste cooking oil (WCO) disposal. Will any type of WCO do for a transesterification process? A quality assessment. *Journal of Environmental Management*, *228*, 117–129. https://doi.org/10.1016/J.JENVMAN.2018.08.106

Costa, M. J., Silva, M. R. L., Ferreira, E. E. A., Carvalho, A. K. F., Basso, R. C., Pereira, E. B., de Castro, H. F., Mendes, A. A., & Hirata, D. B. (2020). Enzymatic biodiesel production by hydroesterification using waste cooking oil as feedstock. *Chemical Engineering and Processing - Process Intensification*, *157*(August), 108131. https://doi.org/10.1016/j.cep.2020.108131

Davoodbasha, M. A., Pugazhendhi, A., Kim, J. W., Lee, S. Y., & Nooruddin, T. (2021). Biodiesel production through transesterification of Chlorella vulgaris: Synthesis and characterization of CaO nanocatalyst. *Fuel*, *300*. https://doi.org/10.1016/j.fuel.2021.121018

Dias, J. M., Alvim-Ferraz, M. C. M., & Almeida, M. F. (2008). Comparison of the performance of different homogeneous alkali catalysts during transesterification of waste and virgin oils and evaluation of biodiesel quality. *Fuel*, *87*(17–18), 3572–3578. https://doi.org/10.1016/J.FUEL.2008.06.014

El-Gendy, N. S., & Deriase, S. F. (2015). Waste eggshells for production of biodiesel from different types of waste cooking oil as waste recycling and a renewable energy process. *Energy Sources, Part A: Recovery, Utilization and Environmental Effects*, *37*(10), 1114–1124. https://doi.org/10.1080/15567036.2014.963745

Farooq, M., & Ramli, A. (2015). Biodiesel production from low FFA waste cooking oil using heterogeneous catalyst derived from chicken bones. *Renewable Energy*, *76*, 362–368. https://doi.org/10.1016/J.RENENE.2014.11.042

Foroutan, R., Mohammadi, R., Esmaeili, H., Mirzaee Bektashi, F., & Tamjidi, S. (2020). Transesterification of waste edible oils to biodiesel using calcium oxide@magnesium oxide nanocatalyst. *Waste Management*, *105*, 373–383. https://doi.org/10.1016/J.WASMAN.2020.02.032

Gaur, A., Mishra, S., Chowdhury, S., Baredar, P., & Verma, P. (2020). A review on factor affecting biodiesel production from waste cooking oil: An Indian perspective. *Materials Today: Proceedings*, *46*, 5594–5600. https://doi.org/10.1016/j.matpr.2020.09.432

Gebremariam, S. N., & Marchetti, J. M. (2017). *Biodiesel production technologies : review* (Vol. 5, Issue February). https://doi.org/10.3934/energy.2017.3.425

Kirubakaran, M., & Arul Mozhi Selvan, V. (2018). A comprehensive review of low cost biodiesel production from waste chicken fat. *Renewable and Sustainable Energy Reviews*, *82*, 390–401. https://doi.org/10.1016/J.RSER.2017.09.039

Kulkarni, M. G., & Dalai, A. K. (2006). Waste cooking oil - An economical source for biodiesel: A review. *Industrial and Engineering Chemistry Research*, *45*(9), 2901–2913. https://doi.org/10.1021/ie0510526

Lam, M. K., Lee, K. T., & Mohamed, A. R. (2010). Homogeneous, heterogeneous and enzymatic catalysis for transesterification of high free fatty acid oil (waste cooking oil) to

biodiesel: A review. *Biotechnology Advances*, *28*(4), 500–518. https://doi.org/10.1016/j.biotechadv.2010.03.002

Mathiyazhagan, M., & Ganapathi, a. (2011). Factors Affecting Biodiesel Production. *Research in Plant Biology*, *1*(2), 1–5.

Nainwal, S., Sharma, N., Sharma, A. Sen, Jain, S., & Jain, S. (2015). Cold flow properties improvement of Jatropha curcas biodiesel and waste cooking oil biodiesel using winterization and blending. *Energy*, *89*, 702–707. https://doi.org/10.1016/J.ENERGY.2015.05.147

Online, V. A., Masjuki, H. H., Ching, J. J., & Chong, W. T. (2016). *RSC Advances*. https://doi.org/10.1039/C6RA08062F

S, J. S., S, J. S., & M, J. L. (n.d.). *Review of Various Reaction Parameters and Other Factors Affecting on Production of Chicken Fat Based Biodiesel*. Retrieved July 16, 2022, from http://130.203.136.95/viewdoc/summary?doi=10.1.1.416.2291

Salimi, Z., & Hosseini, S. A. (2019). Study and optimization of conditions of biodiesel production from edible oils using ZnO/BiFeO3 nano magnetic catalyst. *Fuel*, *239*, 1204–1212. https://doi.org/10.1016/J.FUEL.2018.11.125

Seffati, K., Honarvar, B., Esmaeili, H., & Esfandiari, N. (2019). Enhanced biodiesel production from chicken fat using CaO/CuFe2O4 nanocatalyst and its combination with diesel to improve fuel properties. *Fuel*, *235*, 1238–1244. https://doi.org/10.1016/J.FUEL.2018.08.118

Sharma, A., Kodgire, P., & Kachhwaha, S. S. (2020). Investigation of ultrasound-assisted KOH and CaO catalyzed transesterification for biodiesel production from waste cotton-seed cooking oil: Process optimization and conversion rate evaluation. *Journal of Cleaner Production*, *259*, 120982. https://doi.org/10.1016/j.jclepro.2020.120982

Singh, D., Sharma, D., Soni, S. L., Sharma, S., & Sharma, P. K. (2019). Review article A review on feedstocks , production processes , and yield for di ff erent generations of biodiesel. *Fuel*, *October*, 116553. https://doi.org/10.1016/j.fuel.2019.116553

Stojković, I. J., Stamenković, O. S., Povrenović, D. S., & Veljković, V. B. (2014). Purification technologies for crude biodiesel obtained by alkali-catalyzed transesterification. *Renewable and Sustainable Energy Reviews*, *32*, 1–15. https://doi.org/10.1016/J.RSER.2014.01.005

Suzihaque, M. U. H., Alwi, H., Kalthum, U., Abdullah, S., & Haron, N. (2022). Materials

Today : Proceedings Biodiesel production from waste cooking oil : A brief review. *Materials Today: Proceedings*, *xxxx*. https://doi.org/10.1016/j.matpr.2022.04.527

Talebian-Kiakalaieh, A., Amin, N. A. S., & Mazaheri, H. (2013). A review on novel processes of biodiesel production from waste cooking oil. In *Applied Energy* (Vol. 104, pp. 683–710). Elsevier Ltd. https://doi.org/10.1016/j.apenergy.2012.11.061

Tamjidi, S., Esmaeili, H., & Moghadas, B. K. (2021). Performance of functionalized magnetic nanocatalysts and feedstocks on biodiesel production: A review study. In *Journal of Cleaner Production* (Vol. 305). Elsevier Ltd. https://doi.org/10.1016/j.jclepro.2021.127200

Topare, N. S., Patil, K. D., & Khedkar, S. V. (2021). Effects of operating parameters on biodiesel production from waste cooking oil under ultrasonic irradiation. *Materials Today: Proceedings*, *46*(xxxx), 10638–10641. https://doi.org/10.1016/j.matpr.2021.01.379

Utlu, Z. (2007). Evaluation of biodiesel fuel obtained from waste cooking oilEvaluation. *Energy Sources, Part A: Recovery, Utilization and Environmental Effects*, *29*(14), 1295–1304. https://doi.org/10.1080/00908310500434564

Viriya-empikul, N., Krasae, P., Puttasawat, B., Yoosuk, B., Chollacoop, N., & Faungnawakij, K. (2010). Waste shells of mollusk and egg as biodiesel production catalysts. *Bioresource Technology*, *101*(10), 3765–3767. https://doi.org/10.1016/J.BIORTECH.2009.12.079

Yaman, S. (2004). Pyrolysis of biomass to produce fuels and chemical feedstocks. *Energy Conversion and Management*, *45*(5), 651–671. https://doi.org/10.1016/S0196-8904(03)00177-8

MANAV RACHNA
Vidyanatariksha

Swami Vivekananda Library and Resource Centre
Manav Rachna University

SIMILARITY VERIFICATION CERTIFICATE

Title: Biodiesel production from Waste Cooking oil using Hetero-geneous catalyst & its purification using an organic adsorbent

Researcher: Monika

Registration Number: MRUCHDN012K210013

Supervisor: Dr. Sangita Banga

Department: Deptt. of Sciences (Chemistry)

This is to certify that the above mentioned Short Synopsis/Thesis was scanned for similarity index through Turnitin Software on 21.06.2023 with submission ID 2120137824 and the similarity index was found to be .....6.....%. The complete report running into 25 Pages, 6170 Word count with File Size 3396 KB is being forwarded to the Research Supervisor/DRC/DRB for review.

Date: 21/6/2023

Swami Vivekananda Library and Resource Centre Faridabad
Manav Rachna University
21/6/2023

After excluding 1 Research papers co-authored with the Research Supervisor, as annexed as A-1

The complete report of the above Short Synopsis/Thesis has been reviewed and the similarity index is below the accepted norms as per the University Grants Commission (Promotion of Academic Integrity and Prevention of Plagiarism in Higher Educational Institutions) Regulations 2018. The Short Synopsis/Thesis may be considered for further processing

Monika 21/6/23
Research Scholar

Sangita
Research Supervisor

Scanned with CamScanner

Monika_Short_Synopsis_21.06.2023

by Monika Mru 1

Submission date: 21-Jun-2023 10:34AM (UTC+0530)
Submission ID: 2120137824
File name: Monika_Short_Synopsis_21.06.2023.doc (482.5K)
Word count: 6170
Character count: 36461

Scanned with CamScanner

Biodiesel Production from Waste Cooking Oil using Heterogeneous Catalyst & its Purification using an Organic Adsorbent

Short Synopsis

By

Monika

Regd. No.- MRUCHDN012K210013

Under the supervision of

Dr. Sangeeta Banga, (Professor)

Co-Supervisor

Dr. Vinayak V. Pathak, Manager

EnviorNet Pvt. Ltd.

Department of Sciences (Chemistry)

Year 2023

ABSTRACT

Energy sector is a very crucial sector for the development of any country. As population is increasing very rapidly, the requirement of energy has been increased, leading to depletion of fossil fuels. As we know, fossil fuels are limited in supply and non-renewable, an alternative of these conventional fossil fuels is the need of the hour. Biodiesel is the most promising emerging alternative of conventional fossil fuels. Waste cooking oil (WCO) is a very economical and convenient feedstock for the production of biodiesel. Biodiesel is produced from WCO by the transesterification reaction in which alcohol and a catalyst is added to the WCO to produce biodiesel and glycerol. This study includes transesterification of waste cooking oil to produce biodiesel using various heterogenous catalyst and its purification using an organic adsorbent.

Keywords - Biodiesel; heterogeneous catalyst; waste cooking oil; transesterification; Purification

Scanned with CamScanner

After excluding 4 Research papers co-authored with the Research Supervisor, as annexed as A1

Monika_Short_Synopsis_21.06.2023

ORIGINALITY REPORT

Excluding matches less than 14 words

6%	6%	8%	2%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	biodieseleducation.org Internet Source	1%
2	Digambar Singh, Dilip Sharma, S.L. Soni, Sumit Sharma, Pushpendra Kumar Sharma, Amit Jhalani. "A review on feedstocks, production processes, and yield for different generations of biodiesel", Fuel, 2020 Publication	1%
3	"Nano - and Biocatalysts for Biodiesel Production", Wiley, 2021 Publication	<1%
4	Submitted to University of Hull Student Paper	<1%
5	ksrct.ac.in Internet Source	<1%
6	Anietie Okon Etim, Chiazor Faustina Jisieike, Taiwo Hassan Ibrahim, Eriola Betiku. "Biodiesel and its properties", Elsevier BV, 2022 Publication	<1%

Scanned with CamScanner

7	Ray Vern Quah, Yie Hua Tan, N.M. Mubarak, Mohammad Khalid, E.C. Abdullah, Cirilo Nolasco-Hipolito. "An overview of biodiesel production using recyclable biomass and non-biomass derived magnetic catalysts", Journal of Environmental Chemical Engineering, 2019 Publication	<1 %
8	Sajad Tamjidi, Hossein Esmaeili, Bahareh Kamyab Moghadas. "Performance of functionalized magnetic nanocatalysts and feedstocks on biodiesel production: A review study", Journal of Cleaner Production, 2021 Publication	<1 %
9	Teresa M. Mata, Nelson Cardoso, Mariana Ornelas, Soraia Neves, Nídia S. Caetano. "Evaluation of Two Purification Methods of Biodiesel from Beef Tallow, Pork Lard, and Chicken Fat", Energy & Fuels, 2011 Publication	<1 %
10	Submitted to University of Malaya Student Paper	<1 %
11	Lisandra Rocha-Meneses, Anjana Hari, Abrar Inayat, Latifa A. Yousef et al. "Recent advances on biodiesel production from waste cooking oil (WCO): A review of reactors, catalysts, and optimization techniques impacting the production", Fuel, 2023 Publication	<1 %

Scanned with CamScanner

12	link.springer.com Internet Source	<1 %
13	www.mdpi.com Internet Source	<1 %
14	"Bioenergy Research: Revisiting Latest Development", Springer Science and Business Media LLC, 2021 Publication	<1 %
15	Shamala Gowri Krishnan, Fei-ling Pua, Fan Zhang. "A review of magnetic solid catalyst development for sustainable biodiesel production", Biomass and Bioenergy, 2021 Publication	<1 %
16	Submitted to University of KwaZulu-Natal Student Paper	<1 %

Exclude quotes Off

Exclude bibliography On

Exclude matches < 14 words

Scanned with CamScanner

Energy Nexus 10 (2023) 100209

Contents lists available at ScienceDirect

Energy Nexus

journal homepage: www.elsevier.com/locate/nexus

Biodiesel production from waste cooking oil: A comprehensive review on the application of heterogenous catalysts

Monika[a,b,*], Sangita Banga[a], Vinayak V. Pathak[a]

[a] Department of Chemistry, Manav Rachna University, Faridabad, (Haryana) India
[b] Government college for Women, Faridabad (Haryana) India

ARTICLE INFO

Keywords:
Biofuel
Fossil fuels
Heterogeneous catalyst
Waste cooking oil
Transesterification
Sustainability

ABSTRACT

Development of sustainable energy resources is the need of present day in view of the depleting energy resources and increase in the energy demand throughout the world. On the other hand, fossil fuel combustion emits harmful pollutants like oxides of carbon, sulfur, nitrogen and particulate matters, which causes atmospheric pollution. Biodiesel as alternative fuels have various advantages over the fossil fuels such as its renewability, lesser emission of atmospheric pollutants and flexibility to produce from variety of feedstock. Waste cooking oil can be used as a potential feedstock for biodiesel production. Disposal of waste cooking oil itself an environmental challenge due to its adverse environmental impact. Transesterification is the key process for synthesis of biodiesel production with low cost and under mild reaction condition. Intensive studies have been done on optimization of transesterification for improvement of biodiesel yield and reduction of conversion cost. Heterogeneous catalyst can play crucial role in improvement of biodiesel yield as well as cost of biodiesel production due to their repetitive application. The present manuscript is an attempt to provide comprehensive review on characteristics of waste cooking oil, factors affecting the transesterification reaction and application of heterogenous catalyst in biodiesel production to achieve more sustainability in the process.

1. Introduction

Energy sector of any country is mainly dominated by fossil fuels due to its huge consumption in industrial, transportation and agricultural sector. Depletion of fossil fuels with an alarming rate is a major concern for country like India. The global total energy consumption is 9.938 Mtoe in 2018, out of which oil has maximum contribution of approx. 41% [1], as shown in Fig. 1. The energy requirement of a country is majorly fulfilled by non-renewable conventional energy resources. Due to their limited availability, rapid industrialization and their increasing demand, these conventional fossil fuels are depleting at a very fast rate. So, to find out the best alternative of these conventional fuels is the need of the hour today. Biofuels is the best replacement of these fossil fuels, which are renewable, releases less amount of harmful gasses and have low cost as compared to conventional fossil fuels. Many countries are now emphasizing to use these alternative fuels [2].

Among biofuel, biodiesel is the most promising fuel that can replace conventional fossil fuels. Biodiesel is fatty acid methyl esters (FAME) that are produced from fatty acid esters obtained from some feedstock. Physical and chemical properties of the biodiesel is quite similar to petroleum-based diesel. Biodiesel is produced from biodegradable, renewable and less toxic biomass feedstock. It can be used in existing diesel engine in raw form or in blended form with or without any mechanical modifications. As there is less emission of carbon monoxide and particulate matter, biodiesel provides better engine performance. Biodiesel increases the operational life of an engine, as it has lubricating properties. Moreover, biodiesel is less volatile as it has higher boiling point, thus it's transportation and storage is easy [3]. Due to its higher flash point, it is more energy efficient. Biodiesel has closed carbon cycle means the amount of oxygen absorbed by the oilseed is equivalent to amount of oxygen released during the combustion of biodiesel. There are various feedstocks that can be used for biodiesel production like edible oils, non-edible oils, waste cooking oil, microalgae etc. as it is an oxygenated fuel, it provides complete combustion of fuel thereby increasing its emission profile.

Waste Cooking oil (WCO) serves as a good feedstock for biodiesel production. Most of the WCO is disposed into dustbin or drainage system or onto soil. Their disposal creates many environmental issues also. Instead of disposing, WCO can be used as a feedstock for biodiesel production. Using WCO as a feedstock for biodiesel production will makes the process very economical, due to its low cost. In comparison to edible oils, WCO does not create food vs fuel crisis, it is easily available and does not cause any environmental issue. Only issue with WCO is that it has very high FFA and water content making its transesterification reaction very difficult. So WCO has to give pretreatment or esterification with an acid first before its transesterification reaction [4].

* Corresponding author.
E-mail address: monika7490@gmail.com.

https://doi.org/10.1016/j.nexus.2023.100209
Received 21 March 2023; Received in revised form 8 May 2023; Accepted 24 May 2023
Available online 28 May 2023
2772-4271/© 2023 The Author(s). Published by Elsevier Ltd. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/)

Scanned with CamScanner